Abstract

In the biomedical world, inductive links are long since valued for their ability to transmit electric power transcutaneously. They are employed for wireless powering of implants when the limited energy budget of batteries just is inadequate. Also data communication can be established in both directions over an inductive link. Especially the combination of power and data transmission makes an inductive link very attractive for certain applications. It enables the fabrication of highly integrated and cheap transponders, as are encountered in typical radio frequency identification (RFID) applications for instance.

This book starts its discourse with the fundamental physics of magnetic induction. As a next step, the design equations for an inductive power link are worked out. The appropriate variables are introduced to gain a clear insight into the impact of design choices on the link performance. Methods are provided for optimising an inductive link with respect to power transmission, efficiency or coupling sensitivity. A separate chapter is devoted to the power electronics required for effectively transmitting and receiving power, being an inverter, a rectifier and possibly a voltage regulator. All suitable topologies are considered. Issues regarding design and practical realisation are treated as well.

Novel applications pose new challenges. Inductive powering of a capsule endoscope is a good illustration thereof. The random orientation and position of such a capsule within the abdominal volume demands for novel concepts regarding magnetic coupling. Two possible approaches towards omnidirectional coupling are presented, one encompassing multiple external coils, the other integrating multiple coils at the receiving side. Both concepts are investigated on a general, theoretical basis and techniques are presented by which their worst-case performance can be assessed. For inductive powering of a capsule endoscope, three orthogonal receiving coils turn out to yield the best result in terms of transmitted power and efficiency.

The developed theory is put into practise through the actual realisation of an inductive link for a capsule endoscope. The experimental findings obtained with the realised test model confirm the theoretical predictions. The transmission of at least 150 mW of usable power is demonstrated for all possible positions and orientations of the capsule within the abdominal volume.

Issues regarding the interaction with biological tissue are addressed. The existing literature on biological effects of electromagnetic fields is summarised in a separate chapter. The compliance with the exposure regulations of the inductive link for the capsule endoscope is checked. A conductive shield is applied to the transmitting coil to prohibit any capacitive interaction with the patient's body. This brings the whole-body dissipation down below the prescribed levels and eliminates the possibility of the patient detuning the resonant coil driver by movement of his trunk or arms.

Changes in self-inductance of the transmitting coil, provoked by mechanical deformation for instance, are not supported in a resonant inverter topology. Advanced coil drivers incorporating dedicated control systems are required for driving flexible or deformable coils. The final chapter of this book presents a closed-loop class E inverter topology that compensates automatically for changes in transmitting coil inductance by means of a transductor, which is an inductor with an electrically controllable inductance value. The principal advantage of transductor compensation over earlier reported techniques, is that the operation frequency remains fixed. The realised laboratory test model copes with inductance variations up to 27% without the class E efficiency ($> 80\%$) or the magnetomotive force (125 to 138 ampere-turns) being notably affected.

Springer

http://www.springer.com/978-1-4020-9074-5

Omnidirectional Inductive Powering for Biomedical Implants
Lenaerts, B.; Puers, R.
2009, XVI, 222 p., Hardcover
ISBN: 978-1-4020-9074-5